U.S. Department
of Transportation

**Maritime
Administration**

400 Seventh Street, S.W.
Washington, D.C. 20590

# DESIGN LETTER NO. 3

August 1, 1983
(Reissued January 4, 1991)
(Editorial Changes)

Subject: **MARAD Damaged Stability Standard**

References: (a) Maritime Administration Damage Stability Standard, Design Letter No. 3, August 1, 1983

(b) Principles of Naval Architecture, Vol. I, SNAME, 1988

(c) Definition of Margin Line, 46 CFR 171.015

(d) USCG Wind Heel Criteria, 46 CFR 170.160-173

## I. INTRODUCTION

The Administration requires that all major vessels built under Government subsidy or mortgage guarantee programs be capable of surviving flooding of any one compartment. This letter updates Reference (a) and outlines the specific requirements for the meeting of a one-compartment standard.

In the event that USCG regulations impose more severe requirements, e.g., a two-compartment standard for a tanker of 492' (150 m) or more, then the MARAD one-compartment standard is superseded by those regulations. However, in those cases where USCG damaged stability requirements are nonexistent or less stringent, e.g., dry cargo ships, including RO/RO's, then these MARAD standards for a one-compartment ship are applicable.

## II. DEFINITIONS

a. **Major Vessel:** The Administration reserves the right to determine on a case basis whether a vessel is to be considered a "major vessel". However, in general, the following are major vessels: bulk carriers, breakbulk freighters, oil-bulk-ore carriers, tankers, container-ships, RO/RO vessels, LASH vessels, integrated tug/barges, passenger ships, liquified natural gas carriers, chemical carriers, mobile offshore drilling units, heavy lift ships, and pipe laying ships. In general, the following are not major vessels: tugs (ocean or inland), barges, ferries, fishing boats, and crew boats. Unconventional hull forms, e.g., small waterplane area twin hull (SWATH) vessels, would be considered major vessels or not major vessels depending on their functions; e.g., a SWATH cargo vessel vs. a SWATH tugboat.

b. **One-compartment Standard:** The ability of a vessel to survive flooding caused by damage to the shell to the prescribed extent. This flooding may consist of water entering through the damage opening itself, progressive flooding through non-tight openings or accesses, and downflooding through deck openings. Flooding, in accordance with the required extent of damage and the proper permeabilities, is to be considered to continue until an equilibrium waterline is reached.

c. **Equilibrium Waterline:** The final waterline, after all flooding (through the damage opening, from downflooding, from progressive flooding, etc.) and run-off, if any, has been completed and the ship has reached its final balance condition.

d. **Intermediate Stages of Flooding:** The condition of the ship at any point after damage and prior to reaching equilibrium.

e. **Extent of Damage:** A physical opening of dimensions given below in the side of the vessel resulting in a loss of buoyancy. This extent of damage does not apply across main transverse bulkheads unless they are spaced closer than the required length of damage. **Longitudinal extent** of side damage equals $.495L^{2/3}$ or 47.5', whichever is less (L is length between perpendiculars in feet). **Transverse extent** of side damage equals Beam/5, where beam equals the maximum beam of the ship on the summer load waterline. Transverse damage is measured horizontally from the shell (at the longitudinal location of damage and the summer load waterline) inboard, perpendicular to the ship's centerline. **Vertical extent** of side damage is unlimited above and below the baseline. Note that bottom damage inboard of Beam/5 need not be considered. Note also that these are maximum extents of damage. If lesser extents result in worse conditions, then those conditions must be investigated. For example, if a wing tank width is less than Beam/5 in width, side damage can penetrate to the hold, opening both the wing tank and the hold to flooding water. However, lesser damage that did not reach the hold but opened an empty wing tank might result in a more severe heel angle.

f. **Main Transverse Bulkhead:** Generally a transverse bulkhead extending from shell to shell and from bottom to bulkhead deck. On a case-by-case basis, bulkheads in wing tanks may be considered as main transverse bulkheads (meaning that the damage length need not be considered across the bulkhead). Bulkhead longitudinal steps or recesses less than 10' in length are permissible. These should be treated in accordance with guidelines on equivalent plan bulkheads contained in Section 7.6 (e) of Chapter III, p. 192 of Reference (b). It should be emphasized that stepped or recessed bulkheads increase the likelihood that a bulkhead may be damaged, and their use is therefore discouraged by the Administration.

g. **Downflooding:** The entering of water into a space through an opening (e.g., vents on the weather deck) that becomes submerged after damage, either by the equilibrium waterline or at some point in a reasonable range of stability after damage.

h. **Counterflooding/Crossflooding:** The deliberate flooding of a space to allow a ship to survive damage by offsetting the effects of the flooding caused by damage. Counterflooding/crossflooding should be accomplished passively (for example by crossflooding ducts that are always open). Counterflooding/ crossflooding shall be complete within 15 minutes after damage.

## III. SURVIVAL

In order to "survive" damage to any one compartment, the following conditions, after the equilibrium waterline is reached, must be met (refer to the sketch below). The conditions below are to be used for both symmetric and unsymmetric damage.

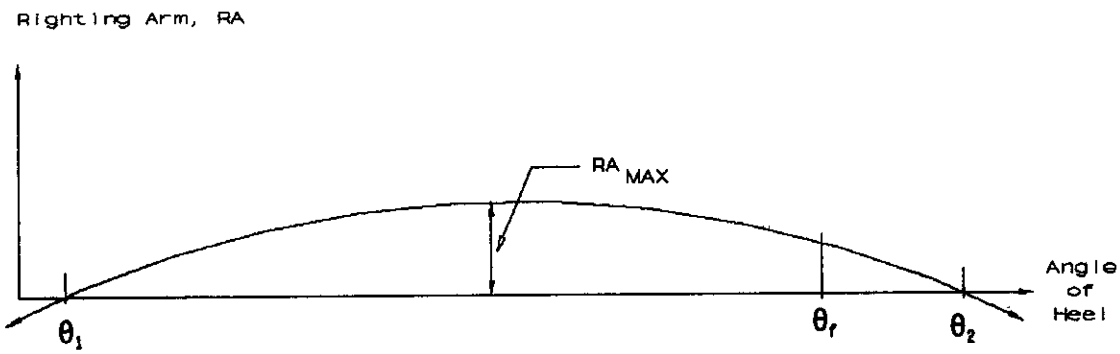
a. Equilibrium heel angle, $\theta_1$, less than or equal to 15 degrees.

b. Downflooding points must not be submerged at $\theta_1$ unless fitted with watertight closing appliances, which then must remain shut at sea and be so logged.

c. Margin line, as defined in Reference (c), not submerged at $\theta_1$, unless it can be clearly shown that downflooding will not occur. To demonstrate this fact it is necessary to submit plans of ventilation system intake and exhaust plenum locations, tank fill and vent locations, tank vent check valve arrangements, etc.

d. There must be a range of positive stability of at least 20 degrees beyond the damage equilibrium heel angle ($\theta_2$ minus $\theta_1$ must be at least 20 degrees, unless unrestricted downflooding occurs at $\theta_f$, in which case $\theta_f$ minus $\theta_1$ must be at least 20 degrees). Downflooding points immersed within the above range must be fitted with weathertight closing appliances. To demonstrate this fact it is necessary to submit plans of ventilation system intake and exhaust plenum locations, tank fill and vent locations, tank vent check valve arrangements, etc. Note that tonnage openings and automatic tank vent check valves are considered weathertight.

e. The maximum righting arm within the above range must be at least 4" ($RA_{max}$ must be at least 4").




f. For cases of symmetric damage, the vessel must have a minimum of 2" of positive GM in the upright condition after damage.

g. Passive counterflooding/crossflooding is permissible on a case-by-case basis. However, in all cases of counterflooding/ crossflooding required to ensure survivability, the Administration's specific approval is required. Obtaining approval from the Administration will require investigation of the effects of intermediate stages of flooding. For example, if an equilibrium waterline before crossflooding has a heel angle of only a few degrees over the limit, the crossflooding would be allowed. However, if immediate crossflooding is required to prevent capsizing, other solutions will be required.

h. In general, survival at intermediate stages of flooding need not be analyzed except as discussed in paragraph g. above. Also, if due to unusual geometry or combinations of loading conditions, intermediate stages of flooding might result in more severe heel and trim angles than at equilibrium, these intermediate stages of flooding must be investigated. For example, side damage to a high, pressed up wing tank with only a small penetration through to the hold could result in a large instantaneous run-off and slow flooding to the hold. An intermediate condition might have the vessel capsizing to the opposite side of the damage, whereas an equilibrium condition (assuming the ship were restrained from capsizing until equilibrium were reached) might have only a slight list to the undamaged side.

## IV. PERMEABILITIES

In general, permeabilities should be assigned as follows:

| Space | | Permeability |
|---|---|---|
| Machinery | | 85 |
| Tanks | | 0 or 95* |
| Spaces with Substantial Quantities of Cargo, Coal or Stores (except Containers or RO/RO) | | 60 |
| Container Holds | | 70 |
| RO/RO Holds: | Containers on Deck | 80 |
| | Containers on Wheels | 90 |
| | Average Value | 85 |

*whichever leads to a more severe condition

Note that these are guidelines. Permeabilities should be rationally chosen so as to agree with the actual vessel loading conditions. For example, if the vessel had a cargo hold essentially empty in a light condition, a permeability of 95 should be used instead of 60. The Administration reserves the right to require additional analyses if seemingly inconsistent permeabilities are chosen.

## V. FREE SURFACE

A free surface correction for each loading condition should be applied as follows:

a. A correction should be made for the single tank or pair of tanks, excluding the fuel oil settlers, having the greatest free surface for each consumable liquid carried in the ship. The correction for this tank or pair of tanks should be calculated assuming it is filled to the point that causes the maximum free surface.

b. A correction should also be made for the fuel oil settlers and/or day tanks, considering each of them to be filled to the point that causes the maximum free surface.

c. In addition, a correction should be made for all remaining slack tanks in the ship. This correction should be based on the actual level of the liquids in the tanks.

d. If, during the course of a voyage,it is necessary to add or remove liquids from tanks other than those considered under items 1 and 2 above, the ship must have sufficient stability to withstand the free surfaces of these liquids, as these tanks are being filled or emptied.

e. Calculations of the effect of free surface may be performed over the full range of heel angles using the moment of transference method. As an alternative, a single correction can be applied at all angles of heel by calculating the free surface assuming the ship is heeled 5 degrees.

## VI. RUN-OFF

In cases where spaces containing liquid or "quasi-solid" materials (QCM ballast or drilling mud ballast) the run-off of these materials should be accounted for by recalculating the displacement and longitudinal, vertical, and transverse centers of gravity of the vessel after run-off.

Where tanks or spaces contain liquids (fuel oil, water, etc.), the entire contents of the space prior to damage is assumed to run out after damage. Flooding water then refills the space at the appropriate permeability (generally 95) to the equilibrium waterline.

Where tanks or spaces contain "quasi-solids", the extent of run-off is defined as follows. The longitudinal extent of run-off is the damage length plus the distance forward and aft to the nearest tight or non-tight solid floor beyond the damage length within the space being considered. The transverse extent of run-off is Beam/5 inboard from the shell plus the distance to the nearest tight or non-tight solid longitudinal inboard from Beam/5 from the shell. The vertical extent of run-off is to the top of the space being considered or the top of the material in the space, whichever is less.

All material within these extents of run-off is assumed to run out and is replaced with flooding water to the equilibrium waterline. All other material within the space is assumed to remain in place. If this material is permeable, then flooding water is assumed to run into it at the appropriate permeability.

## VII. REQUIRED INFORMATION TO BE SUBMITTED TO THE ADMINISTRATION

a. **Nine Standard Loading Conditions:** Generally, it must be demonstrated that the nine combinations of full, half, and no cargo with full, half, and 10 percent consumables meet the one-compartment standard. However, the basic distribution of load items (for example, in a full load condition with full consumables, cargo holds full, wing tanks full, and double bottom tanks full) becomes a required operating condition which must be met if no other combinations are analyzed. For instance, in the example above the vessel would not be allowed to operate with empty double bottom tanks without further analysis.

b. **Required Operating Condition**: These can be circumvented completely by a comprehensive analysis resulting in a limiting KG (or required GM) versus draft curve. For a given loading condition (for example, 50 percent cargo, 10 percent consumables) and the corresponding draft, all combinations of tank and hold loadings that can reasonably be expected should be analyzed and the worst case and its limiting KG determined. If the operator does not exceed that limiting KG at the draft, then the vessel meets a one-compartment standard without regard to the specific loading distribution. MARAD reserves the right to propose operating conditions in the Trim and Stability Booklet if sufficient combinations are not analyzed to cover reasonably expected loading conditions.

c. **Submittals should include:**

1. Detailed summary of loads, centers, and load distributions for each condition analyzed.

2. Description of extent of damage (length, depth, height, location) and assumed permeabilities for each condition analyzed; also, extent of progressive flooding, counterflooding/ crossflooding (if allowed), any key assumptions, etc.

3. Description of equilibrium condition after damage (drafts, trim, heel, margin line immersion, downflooding points immersed), as well as righting arm values over the range of heel angles, for each condition analyzed.

4. A plot of limiting KG (or required GM) versus draft consisting of the most limiting damage cases and the USCG wind heel criteria, Reference (d).

5. If the Ship Hull Characteristics Program (SHCP) is used, offsets for any irregular compartments defined.

6. General arrangement plans, lines plans, capacity plan, plans showing potential downflooding points (ventilation system plenums, tank vents, cargo hold accesses), and a light ship weight estimate.

## VIII. EXCEPTIONS

In exceptional cases, where compliance with the one-compartment standard would unduly penalize the design and no other practical solution is available, the Administration will consider required operating conditions for cargoes and liquids (for example, the pressing up of a tank when above a certain draft) or other solutions necessary to meet the one-compartment standard. However, the specific written approval of the Administration is required in these cases.

Approved: Charles B. Cherrix Date: Jan. 4, 1991
Charles B. Cherrix
Chief, Division of Naval Architecture